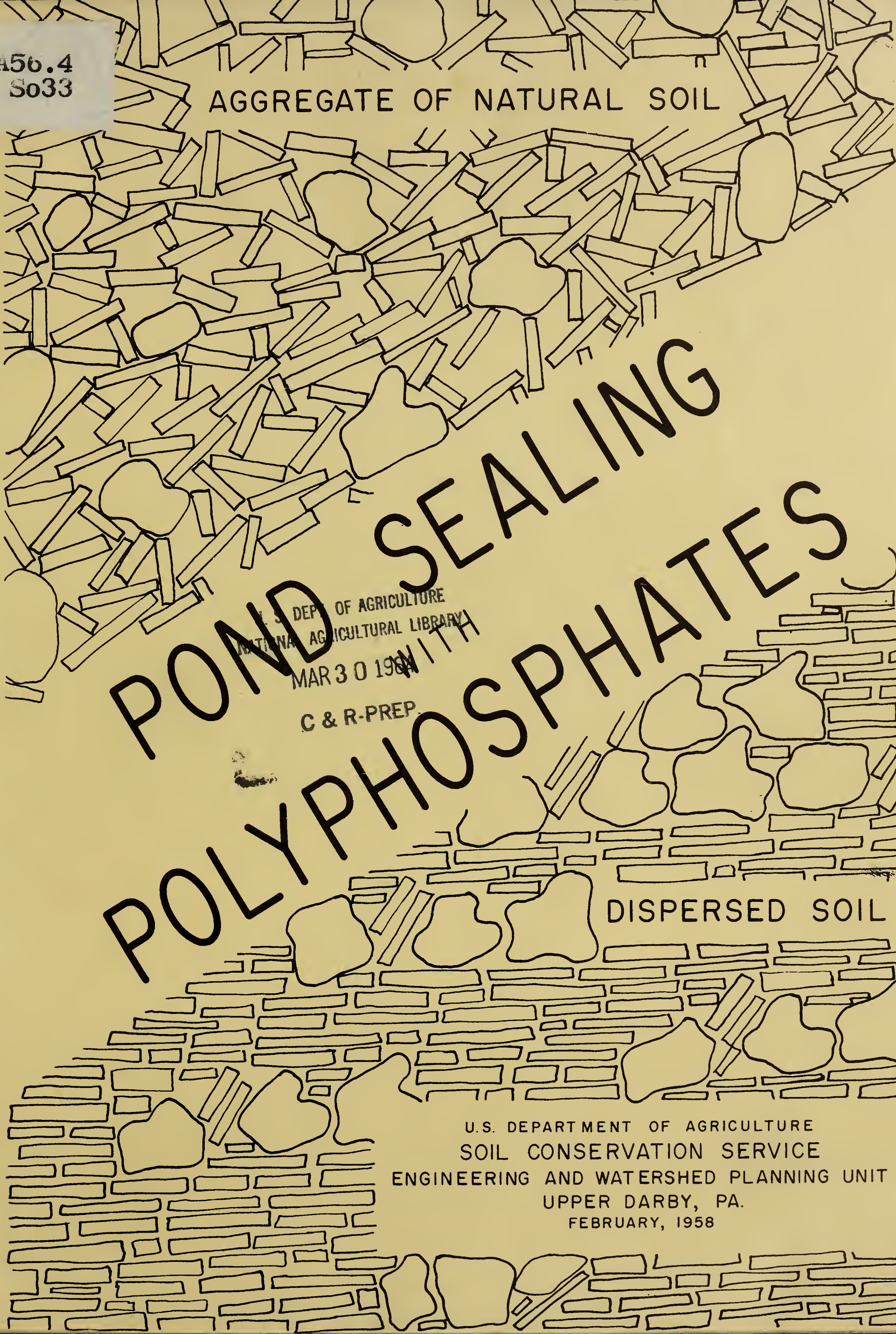
Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

A56.4
So33

POND SEALING WITH POLYPHOSPHATES



U. S. DEPT. OF AGRICULTURE
NATIONAL AGRICULTURAL LIBRARY
MAR 3 0 196[illegible]
C & R-PREP.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING AND WATERSHED PLANNING UNIT
UPPER DARBY, PA.
FEBRUARY, 1958

AD-33 Bookplate
(1-63)

NATIONAL
AGRICULTURAL
LIBRARY

A56.4
So33

64748

64748

ACKNOWLEDGMENTS

Acknowledgments are extended to the Soil Conservation Service engineers of the Northeastern States who requested this report and submitted laboratory and field data to make it possible.

Rey Decker was responsible for the laboratory analysis and interpretation of the reports. The basic laboratory studies had been made and published by T. William Lambe. Fred H. Larson, Head; Glenn W. Grubb, Design & Construction Engineer; G. Robert Hall, Geologist; Gertrude M. Le Kites, Engineering and Watershed Planning Unit; Lester Fox, Information Specialist, SCS, reviewed and offered valuable editorial advice.

Valuable contributions were made by W. S. Atkinson, M. M. Weaver, Jerry I. Tomenga, Royce B. Brower, Frank R. Brower, Jr., Kendall P. Jarvis, George E. Wheeler, William A. Allaband, David H. Pugh, John F. Kane, Harold M. Rhodes, Boyd J. Patton, E. V. Wickline, and many other Soil Conservation Service technicians in soils descriptions, field trials and related services.

TABLE OF CONTENTS

APPENDIX

POND SEALING WITH POLYPHOSPHATES

By Robert F. Fonner*

ABSTRACT

Field trials and laboratory tests of pond sealing have been conducted in widespread areas in the Northeast for the past 25 years. Within the last few years the use of a new family of chemicals, the polyphosphates, has been extensively tried with very promising results.

This paper outlines the scope of the tests. Both field observations and laboratory analysis of over 100 sites were reviewed. Representative observations and laboratory reports are presented in the report.

It was possible to correlate the field trials and laboratory tests with geologic conditions. Accompanying map shows tentative boundaries of four areas.

1. Residual Limestone Area

   Provided enough foundation exists (an adequate cap over open caverns or crevices) a reliable recommendation for pond sealing with polyphosphates can be made in this area based on simple on-site tests and physical properties of the soils.

2. High-Lime Glacial Till Area

   Reliable recommendations can be made based on simple on-site tests and physical properties of the soils. Strata of highly permeable sands and gravels require carefully constructed blanketing to assure success.

3. Piedmont Area

   Conditions vary greatly between sites in this area. Field clues are not conclusive enough to identify sites requiring treatment. Submit samples from each site to the laboratory for analysis and recommendations.

4. Coastal Plain Area

   The percentage of "fines" (silt and clay) in the soil at the particular site appears to govern the need for sealing and the type of additive to be used. This determination can be made only with laboratory equipment.

*Engineering Geologist, Engineering and Watershed Planning Unit, Soil Conservation Service, Upper Darby, Pennsylvania

The reaction between soils and polyphosphates appears to:

1. The combination forms an insoluble stable compound (calcium polyphosphate).

2. Ionic exchanges between sodium and calcium ions develop an unbalanced ionic situation which tends to maintain a dispersed condition of soil particles.

3. Capillary channels and voids which form in untreated soils are filled with dispersed soil particles. The net result is the creation of a relatively stable, impermeable blanket.

Farmers can apply this treatment with equipment ordinarily found on the farm (tractors, fertilizer or lime spreaders, disks, etc.). Costs are much lower than for other acceptable sealing methods. Costs of materials range from $10 to $12 per 100 pounds to treat 2,000 square feet. Total costs at 1957 prices, including labor and equipment, range from $300 to $386 per acre of pond area.

INTRODUCTION

For many years field trials and laboratory tests have been conducted to find an effective and economical sealant for farm ponds. Many effective sealants were known for permeable soils, but the treatment costs were above the limits the farmer or other individuals would pay. Since 1952, many studies have tested chemical effects and behavior upon various soils.

In 1954, T. William Lambe, Massachusetts Institute of Technology, examined a new family of chemicals, polyphosphates, which had a promising effect for use in soil sealing. The polyphosphates dispersed natural soil aggregates. This dispersal resulted in higher maximum densities and lower permeability rates upon compaction.

Using this and related research data, Rey Decker, Soil Conservation Service, Soil Mechanics Laboratory, began testing polyphosphates on samples arriving from the field. The results of permeability, freezing and thawing, and, often, cation exchange tests were the basis of the polyphosphate recommendations. In a 2-year period technicians conducted field trials in nearly 100 ponds in the Northeastern states with very promising results.

The Northeastern U. S. Soil Conservation Service state engineers discussed these trials and results at their fall 1957 meeting in New York. They resolved that the Engineering and Watershed Planning Unit should assemble, correlate and analyze the existing laboratory and field data to furnish guide criteria. The criteria were to enable technicians to make polyphosphate recommendations for pond sealing for certain areas. The recommendations were to be based on simple on-site tests and physical soil properties.

This report explains the action of polyphosphate as a dispersant and sealant. It describes the geology, soils, and soil characteristics of each of the areas where pond sealing is a problem. It interprets laboratory analysis and field trials. It explains methods of application. The conclusions include data on locating the areas and describing the conditions to guide the use of polyphosphate recommendations for soil sealing.

POLYPHOSPHATE - A DISPERSANT

In soil reaction, sodium polyphosphate acts as a dispersant. It breaks down coarse soil aggregates into finer particles. It holds them in this dispersed state and permits them to arrange themselves in a more orderly manner. (See cover) (Sodium polyphosphate is the general name for sodium tripolyphosphate, tetra-sodium-pyrophosphate, and sodium-hexametaphosphate or calgon. It is the ingredient common to most household detergents.)

Chemical Effect of Polyphosphates

Dispersion can be done either mechanically or chemically or both.

Chemical dispersion is more effective for these reasons:

1. When sodium polyphosphate is added to a high calcium soil, the polyphosphate prefers to react with the calcium. The reaction forms a non-ionized compound, leaving the sodium for absorption by the soil.

2. Considerable experimental evidence shows that polyphosphate becomes attached to the surface of the soil. This reaction increases the negative potential of the soil surface. This increases its capacity to absorb cations.

3. The sodium-for-calcium exchange also results in the net effect of an increase of repulsion between soil particles.

4. Since dispersants act by altering surface characteristics of soil particles, they work best with soils of high specific surface. Therefore, they are active with silts and clays and inactive with clean sands and gravels.

Effect on Engineering Properties

Laboratory and field tests prove that polyphosphate has certain effects on the engineering properties of soils.

1. Particle sizes are decreased and plasticity is increased.

2. A dispersed soil can be compacted to a higher dry density and the molding water content for maximum density is lower than for the untreated soil.

3. Since, theoretically, the action of polyphosphate is to reduce soil cohesion or weaken the soil, experiments show (a) the as-molded strength is about the same; (b) the equilibrium water content of the dispersed soil is lower than that of untreated soil; and (c) following the dry-rewet cycle, the unconfined compressive strength of the dispersed soil is higher than that of untreated soil.

4. The major portion of permeability reduction is probably due to the higher order of particle orientation which results in a more tortuous seepage path.

5. Polyphosphates, under freezing and thawing conditions, reduce water pickup and helps the soil retain its strength upon thawing.

AREAS OF POND SEALING PROBLEMS

The general areas of pond sealing problems were selected from field data and laboratory reports. The selection was based on origin of soil, parent material, physical and chemical properties of the soil, problem areas, geology, and soil series.

The general locations are:

1. The residual limestone areas. They extend from the northern tip of New Jersey, southwest across eastern Pennsylvania, into Maryland and West Virginia, and south into the great limestone valley of Virginia.

2. The high lime glacial till areas. They are located south of the Great Lakes in northwest Pennsylvania and New York, encircling the Adirondack area along the St. Lawrence and Mohawk valleys, and extending south along western Vermont, Massachusetts and Connecticut.

3. The piedmont area of New Jersey, Pennsylvania, Maryland and Virginia.

4. The sandy coastal plain area bordering the Atlantic seacoast from Long Island through Virginia.

Residual Limestone Areas

In the residual limestone areas, we have long been aware of pond sealing problems. The principal limestones and dolomites are deeply weathered and fractured. Often they contain numerous crevices and solution channels.

The principal geologic formations in these areas are:

Age	Series	Maximum Thickness (ft.)	Description
Mississippian	Greenbrier	1,000	Gray and brown Siliceous limestone.
Devonian	Helderberg	500	Massive dark-blue limestones interbedded with calcareous shales and chert layers.
Silurian	Rondout	500	Waterlime, shaly limestone and calcareous shales.
	Bossardville	500	Blue gray thin bedded limestone, fossiliferous.
	Niagara	400	Shaly limestones and calcareous shales blue gray.
Ordovician	Trenton Chambersburg (Conestoga)	600	Shaly limestone
	Stones River (Chazy)	800	Range from pure limestone to dolomite.
	Beekmantown	2,000	Chert, dolomitic limestone, limestone.

Age	Series	Maximum Thickness (ft.)	Description
Cambrian	Conococheaque	1,500	Thick bedded siliceous banded limestone.
	Elbrook	3,000	Light blue and gray shaly limestone.
	Tomstown (Ledger, Kinzer, and Vintage)	1,000	Shaly dolomitic marble and limestone with thin shales.

The principal soils in this limestone area that have failed as pond material without treatment are:

Araby	Hagerstown
Brooke	Murrill
Clarksburg	Ryder
Conestoga	Strasburg
Duffield	Washington
Frankstown	Wiltshire
Frederick	

Other limestone soils exist within the area but have not been laboratory tested for their sealing characteristics.

The mechanical analysis of the fines falls in this range from 52 sites in the residual limestone areas.

Silt %	Clay (.002mm) %	Clay (.005 mm) %	Treatment	Classification
19-75	17-59	12-59	TSPP*	ML CL-ML CL

The above soils indicate similar physical properties in pH, structure and silty nature.

The pH range in the subsoil is 6.5-8.0. Soil structure is usually granular or crumb (in the upper horizons). Flocculation and aggregation result from alternating wetting-drying and freezing-thawing action on calcareous soils. The lower horizons (B_2-C) exhibit subangular blocky structure to blocky structure. This open soil structure leads the infiltrating water into the numerous crevices, fractures and solution channels known to exist in the underlying limestones, dolomites and calcareous shales. After ponds have been built, observations and laboratory reports indicate that these soils tend to revert to the original structure after it has been destroyed during construction.

Polyphosphate treatment appears successful throughout this area after two years of trial.

*Tetra-sodium-pyrophosphate, 1 lb./20 sq. ft.

High Lime Glacial Till Areas

During the Wisconsin glacial period, a vast ice sheet moved southward. It scoured, gouged and ground the limestones and dolomites forming the rim of the Great Lakes-St. Lawrence basin. This debris was carried southward from its source. Some was dropped with the advance of the glacier. The rest was dropped as the ice melted and retreated. The fine silts and rock flour were often transported by the meltwaters and deposited in numerous depressions, small lakes, and valleys which have drained in post-glacial times. This area extends south of Lake Erie and Lake Ontario into northwest Pennsylvania and New York. Other areas in New York affected are the Black River Valley, Mohawk Valley and the Champlain-Hudson Valley which extends into western Vermont, Massachusetts and Connecticut.

The Great Lakes tills are derived from Silurian and Devonian limestones and dolomites. The Champlain-Hudson tills are derived mainly from the Cambrian and Ordovician members.

The offending soils of these areas are mainly:

Homer	Kendaia	Mohawk
Honeoye	Lima	Moira
Ilion	Manheim	Palmyra

These soils exhibit similar physical characteristics to the residual limestone soils, i.e. high pH, blocky structure, high silt and clay content. They may or may not be directly underlain by calcareous bedrock. Often the sites are located in depressions of stratified silts and sands, or, as typical of glacial till, of unsorted gravels, sands and silts.

The results of the mechanical analysis of seven samples are submitted from the high lime glacial till area.

Silt %	Clay (.002mm) %	Clay (.005 mm) %	Treatment	Classification
25-41	5-21	14-37	TSPP	CL-ML

This observation vividly described the problem in high lime glacial till soils.

> "About eight years ago we had constructed several ponds in Wyoming County, New York. We had more or less failure due to leaking in these ponds. The directors of the Soil Conservation District had asked us not to build any more ponds because of the large amount of failures.
>
> "I analyzed the soil in these ponds by the Boyoucus method. They were made up of a fair amount of sand, a small amount of silt, a very little quantity of clay, and a high amount of colloids. Example: sand 45.28, silt 25.68, clay 5.18, colloid 24.86%. The pH of these soils was high.

"These ponds did not all leak immediately upon completion. Over about a two-year period they might either start to leak or stop leaking. In other words, we might build a pond that would hold water for a year or a year and a half and then go dry. Or, we might build a pond which would not hold water from the start and two years later would fill up and remain full. We tried to determine what type of soil was giving us trouble. It seemed that the soil could be compacted and then after applying water, it would swell to the extent that it became pervious.

"Since that time, we have found other ponds in New York State which have given us similar troubles. These were located in the area south of Rochester, the central part of Seneca County, in the area north of Little Falls, Essex County, St. Lawrence County, and near Cazenovia, New York.

"Observation of the ponds shows that some of these soils would crack under water. This, of course, is a rather strange phenomenon. It has been observed in the bottoms of ponds. Other small areas would swell about like a small ant hill. The mound would get higher and higher until finally the top opened up and it seemed to roll outward and downward until the final situation was a small area like a bluegill 'spawning bed' about 12 to 16 inches across with a little dike around it about an inch to two inches high or sometimes the dike did not exist, just a small depression of that size. Usually the inside of these small mounds is a black, brackish substance which is open. You could pass your fingers through it easily after the outside was penetrated. Water was observed to be moving through the resulting little 'spawning bed.' An electrolytic examination of this soil shows it to have a high concentration of one ion. Adding some sort of acid substance seemed to balance it and allow it to remain in compaction.

"Soils from two ponds were put up in glass tubes compacted and wetted - different substances being added to different samples with a control sample of each. The control sample was observed to have produced one of these small mounds which as described got larger and larger and finally opened up on top. Underneath this small mound was a crack which extended down about one-half the depth of the tube.

"When I see a sample of soil which has a very light weight and a very small honeycomb appearance with the indentations being about the size of a pinpoint or a bit larger, I call for a pH test. If the pH is very high I suggest a lab analysis. In no case have we had a leak through the dike or dam. A leak always occurs in the bottom. I have felt that there is a certain depth of soil which puts enough weight on the soil particles which causes them to remain in compaction. This would probably be something over 3 feet of soil as we usually have at least 3 feet of dike above our normal water line.

"This past summer in a pond near Scottsville, New York, this same condition was observed. Digging into the 'spawning beds' about 16 inches down revealed a cavity about 3 feet in diameter and 5 feet deep.

The soil in this cavity had very distinct vertical cleavage. There was a very distinct deposition from the water in these vertical passages. This would indicate that water had been passing through them for some time. The soil which had fallen from the sides of the hole was wet and mushy. That in the very bottom of the hole was quite dry and fairly compact. The material on the sides of the cavity was light in weight, honeycombed and had a high pH.

"This pond had been built about two years. It would fill up every spring and go dry during the summer. The 'spawning beds' were more or less of a straight line along the bottom of the pond.

"I have made a mechanical analysis of quite a few ponds. In most cases, the soils technicians have classified the soils as undifferentiated alluvium. Several of those with which we have had trouble are in or within an area of Lima Silt loam.

"Before the lab was able to help with the problem, we used common cattle salt to seal one pond of this type. This gave fair results although our application methods were poor. Another one was done this fall. We have used tetra-sodium-pyrophosphate on one with excellent results. We have covered the bottom area of one pond with the polyphosphate and are waiting for it to fill."

Piedmont Area

The piedmont area extends from southeast New York through Virginia, east of the limestone areas. Its boundaries include the Blue Ridge mountains and Triassic basins. The geology of the area is complex. The bedrock consists of metamorphic shists, gneisses, slates, marbles, crystalline granites, and diabase. The area is highly fractured, having undergone periods of folding, faulting and many crustal changes.

The following problem soils of the metamorphic piedmont area have been submitted to the laboratory:

Baltimore	Fanquier	Wehadkee
Cardiff	Highfield	
Edgemont	Manor	

The Triassic soils are:

Bermudian	Readington
Penn	Croton

These soils are derived chiefly from red silty shales and sandstones. Of 43 samples tested at the laboratory, 21 (50%) were recommended for TSPP treatment.

The range of fines determined by mechanical analysis of the piedmont soils for these sites are:

Silt %	Clay (.002 mm) %	Clay (.005 mm) %	Treatment	Classification
10-45	10-30	18-50	TSPP	MH-ML

Because of the wide range of conditions that exist, and the sparse data available, it appears that additional trials and testing should be done before identification of soils requiring polyphosphate treatment can be made in the field.

Coastal Plain Area

The coastal plain area extends from Long Island, New York, along the eastern seaboard into Virginia. They consist generally of stratified sands, gravels and clays of Miocene, Eocene and Cretaceous age. Pond sealing is difficult in the Monmouth, Sunderland, Talbot and Wicomico formations.

The soils of this area are:

Beltsville	Sassafras
Coltsneck	Wayside

The existing data indicates that the percentages and behavior of fines, silt and clay are the major determination of the TSPP recommendation.

Seventeen sites were tested, resulting in 15 with TSPP recommendations.

The fines distribution is:

Silt %	Clay (.002 mm) %	Clay (.005 mm) %	Treatment
10-40	10-25	16-40	TSPP

INTERPRETATION OF LABORATORY REPORTS

Since the first recommendation of polyphosphate from the laboratory, subsequent correspondence has been inquiring what criteria and tests are used as a basis. To better understand the laboratory reports and analysis, field technicians are given the following explanation:

Soil Analysis Report (See Figure 2)

Column #1 lists soil laboratory number, Column #2 lists sample numbers designated from the field, Column #3 is for descriptions, Column #4 lists depth of sample taken. This material, except Column #1, is usually field-furnished information. The next columns (5-9) list the mechanical analysis of the sample in percentage by weight of dry sample. The particle size ranges are as follows:

Column 5 - gravel - 10 ..... 1 mm in diameter
6 - sand - 1 ..... .05 mm in diameter
7 - silt - .05 ..... .002 mm in diameter
8 clay - .002 ..... inf mm in diameter

(Column 5 through 8 should equal 100%)

The .005 mm clay listed covers a range from the fine silts through the clays in the sample tested. This would include a part of Column 7 and Column 8. This is separated out to determine the type of sealing additive that will be tested. The laboratory feels that the use of polyphosphates as a seal on samples having less than 15% (.005) clay is questionable. In some cases less than 15% clay has shown satisfactory results in the laboratory. Actual performance in the field, however, will be needed to verify the tests.

Column #10 lists Dispersion. This is the place where the .005 clay enters the picture. The test is a measure of the amount of .005 clay that slakes into suspension without prolonged mechanical agitation or chemical dispersants. Dispersion is a measure of the granular stability of soil. Dispersed soils have no binding power when wet. They slide and erode easily, are subject to piping and seal when puddled. They are also subject to excess settlement. In the first report, the first figure indicates the dispersion of the .005 clay fraction. It is of little significance in most of the soils tested to date. The second figure refers to the silt plus clay dispersion in percent. The laboratory considers anything below 75% not critical. Soils of low dispersion usually are of good aggradation and strength.

Column #11 concerns the salt content. This is an important test in the West but is uncommon in the East. 0.5 percent salt is considered critical from a corrosion standpoint. The next columns relate to the permeability which is reported as coefficient "k" based on cubic foot per square foot per day, at 1:1 head.

Tests are usually based on tests dry tamped (D.T.) and wet tamped compaction (W.T.) alone and then D.T. and W.T. with soil sealing compounds such as the polyphosphates and bentonites. Generally tests with bentonites are made in excessively sandy soils and the polyphosphates are tested on soils with 15 percent or more .005 clay.

The lab makes other tests, such as dry density in pounds per cubic foot and the percent by weight of H_2O necessary to bring the soil to optimum moisture. In sandy soils a further breakdown may be made in sand particle size. Sometimes the permeability is listed below the mechanical analysis to save space. Such listing can be confusing.

Test for K Permeability Coefficient

This test is simple: a sample of soil cross-sectional area (A) is subjected to head of water (h), and the discharge (Q) is measured after a suitable time interval (t). This test satisfies all factors of Darcy's

Equation Q = AKi. The soils lab tests are run under a constant head and the results are reported as feet/day under unit head. The equation used is:

$$K = \frac{Q\ L}{t\ h\ A}$$

K - permeability coefficient
Q - quantity of water flowing in t
h - total head of water plus soil
L - length of sample

Determination of Seal Blanket Thickness

Laboratory results are reported on a 1:1 head considering that head =

$$\frac{\text{length of soil column + water height}}{\text{length of soil column}}$$

Vertical Flow: (leakage through bottoms)
1:1 or Unit Head = saturated soil column topped by an infinitely thin film of water.
2:1 Head = 1 foot of soil topped by 1 foot of water.

Unit head permeability rates must be multiplied by the head expected in the field to calculate field seepage losses. This is important in calculating expected losses through blankets or sealing layers.

The example below illustrates the use of the above information:

Example: given 1 foot blanket of clay with a K value of .001 ft./day at 1:1 head. Depth of water in the pond - 10 feet

The field head is as follows: $\frac{1 + 10}{1}$ or $\frac{11}{1}$ or 11:1

Then field seepage is Q = AKi where A = 1 sq. ft.
K = .001
i = 11

Q = 1 x .001 x 11 or .011 cu. ft./day/sq. ft.

Doubling the blanket thickness will reduce the head and seepage rate thus:

Field head = $\frac{2 + 10}{2}$ or 6:1 or .001 x 6 = .006 cu.ft./sq.ft./day

Horizontal Flow:

Head relationship for horizontal flow such as seepage through the base of the dam is generally less than that for vertical flow through the bottom of the reservoir.

Example: Base width of dam 60 feet
Depth of water 10 feet
Using K .001

$$\text{Hydraulic gradient } (i) = \frac{h}{L} = \frac{\text{difference in head}}{\text{Length of path}} = \frac{10}{60} \text{ or } .166$$

Then Q = AKi or Q = 1 x .001 x .166 or .000166 cu.ft./sq.ft./day

Permeability data is important. It has a direct bearing on the rate and amount of settlement, the depth of cutoffs, selection and placement of blankets or sealing materials, the line of seepage through dams and the design of toe drains.

The Soil Mechanics Laboratory uses a value of "K" of 0.001 cu. ft. per sq.ft./day at 1:1 head as the maximum permeability of an effective seal blanket.

Freezing and Thawing Tests

The freezing and thawing tests consist of alternating freezing and thawing, 4 to 8 days per cycle, for 6 cycles and determining the permeability coefficient after each cycle. The K* values at the end of the test indicate how certain soils and sealants behave under these conditions.

Often the K value on wet compaction indicates a slow permeability but, through alternating freezing and thawing, the permeability rapidly increases. The addition of salt or polyphosphate to the sample usually decreases the permeability during and after the freezing and thawing tests. Even though salt often produces results comparable to those of polyphosphate, economy and the temporary effect of salt often rules it out of the recommendation.

> "You may perhaps wonder why our recommendation calls for treatment beyond construction of a simple wet rolled blanket. We have found that sealing blankets developed by wet rolling only and without benefit of an additive do not stand up too well and are adversely affected by alternate periods of freeze-thaw or wetting and drying."

This recommendation has appeared on several reports from piedmont and coastal plains samples. Freezing and thawing effect should not be overlooked.

The freezing and thawing tests of the Eisenhower and Sharp ponds, Pennsylvania, are shown on Figures 3 and 4.

RECOMMENDATIONS

The recommendations for design and construction are usually brief and attached to the Soil Analysis Report.

In the residual limestone and high lime glacial till areas the typical recommendation reads:

"1. Tetra-sodium-pyrophosphate should be applied at the rate of 1 pound per 20 square feet over the area to be sealed and thoroughly mixed with the soil to about an 8 inch depth.

*Permeability coefficient

"2. The TSPP-soil mixture should be about ______* pcf dry density at about ______* percent moisture."

In other areas the laboratory not only recommends a sealant but suggests methods for obtaining an effective seal in doubtful areas. (Figure 5)

"You will note that wet compacting this sample produced an impervious seal. It is felt, however, that polyphosphate should be added to the wet compacted treatment to insure longevity.

"You mention that two feet of material will be removed from the pond floor. Is this material to be removed similar to the sample or otherwise?

"It must be assumed that material to be removed is not suitable for sealing and will be replaced by the sample material. In such case, it is recommended that at least one foot of the replacement material be placed over the floor and sides of the pond. It would be well to compact the bottom lift in this replacement before adding the top six inches and mixing the polyphosphate. This procedure would result in one foot of compacted material with polyphosphate in the top blanket and should produce an excellent seal blanket."

APPLICATION

Sealing farm ponds with polyphosphate can usually be done with farm equipment if adequate moisture and compaction are provided.

Begin installation of the chemical liner by smoothing the inside of the reservoir and removing any organic matter. Cover rock outcrops or other bad areas with 24 to 36 inches of as good subsoil as is readily available. In cavernous limestone areas, the success or failure of the seal may depend upon the thickness and compaction of this blanket. (Caution: As polyphosphate moves deeper into natural soil and rock below the blanket, soil cohesion is weakened and additional caving might result.) Pulverize eight inches of the soil to be treated with an ordinary farm disk and broadcast or drill granulated polyphosphate (granular form is preferred but it is also available in powder) at the rate of 1 pound per 20 square feet over the area.

If broadcasting is used, stake out the area in 200 square feet grids. One gallon can will hold 10 pounds of polyphosphate.

After the sealant has been applied mix it thoroughly with the soil at optimum moisture conditions and compact it to or near maximum density. Under these conditions an effective seal blanket can be achieved.

If a thicker, 12 to 24 inch, blanket is required, the soil should be mixed and compacted in 6 to 8 inch lifts.

---

* From Soil Analysis Report

A sheepsfoot roller does an excellent job, although a farm tractor will do an acceptable job, also. The soil should have just enough moisture so that a handful sticks together when squeezed tightly. The polyphosphate releases water in the soil. The job can easily become too wet to handle, therefore. In cases where the soil to be treated is too dry, sprinkle the treated layer with water during the mixing operation.

After installing a liner, mulch the entire treated area with straw. This prevents cracking as well as gullying on the sides which would cut through the liner if allowed to go unchecked. Riprap with heavy stone any points where concentrated volumes of water flow into the pond. This prevents cutting through the liner at these critical points. Fence the pond to avoid cattle tramping.

Water in a treated pond will stay muddy for many weeks because of the extremely fine clay particles suspended as a result of the dispersing action of the chemical. The water will clear, however.

COMPARATIVE COSTS

The cost of polyphosphate treatment is from 5 to 10 times lower than those for other sealants such as bentonite, soil cement, plastic liners, etc.

The table below reports the cost of TSPP sealing an acre surface area at the rate of 1 pound per 20 square feet.

State	Polyphosphate*	Labor & Equipment	Total
Maryland	$200**	$100**	$300
New York	203	183	386
Virginia	210	100**	310**
West Virginia	240	100**	350**

SCS personnel reported these costs. The figures do not include engineering services, soil testing and supervision.

CONCLUSIONS

Promising results have resulted from trials of pond sealing with polyphosphates. Over 100 sites have been tested and half of these received polyphosphate treatment. After trials of two years or less, they have been called successful.

It was possible to correlate the field trials and laboratory tests with geologic conditions in two of the four areas. These areas are shown on Figure 1.

---

* Based on 1957 prices delivered to the site.

Bentonite is priced from $50 to $80 per ton (1957.

** Estimated

1. Residual limestone areas.

Provided sufficient foundation exists (an adequate cap over open caverns and crevices) reliable recommendations for pond sealing can be made through the use of simple field tests and physical properties of the soils.

The identifying features should be:

(a) high pH 6.5 to 8
(b) subangular blocky to blocky structure
(c) medium to high silt content with at least 15 percent clay, ML, MH, CL
(d) low plasticity

2. High lime glacial till areas.

Reliable recommendations can be made with similar on-site tests and physical properties of the soils as noted in the residual limestone areas. Strata of highly permeable sands and gravels require carefully constructed blanket seals and drainage to assure success.

3. Piedmont area.

Conditions are highly variable between sites in regard to geology and soils. Successful treatment with polyphosphate appeared possible in 50 percent of the samples tested. From the data, the silt and clay relationship appeared to be one of the governing factors. Field clues were not conclusive. Submit samples from these sites to the laboratory for analysis and recommendations.

4. Coastal Plain area.

The percentage of silt and clay fines in the soil at each site appeared to govern the need for sealing and the type of additive to be used. The laboratory criteria require a minimum of 15 percent .005 clay in these sandy soils before testing with polyphosphates. This determination requires laboratory analysis.

The reaction between soils and polyphosphates appears to:

1. Form an insoluble stable compound, calcium-polyphosphate in high lime soils.

2. Permit ionic exchanges between sodium and calcium ions and create a repulsion effect between soil particles which maintains the dispersed condition even through freezing-thawing cycles.

3. Fill capillary channels and voids with dispersed soil particles resulting in greater density and reduced permeability upon compaction.

The net result is the creation of a relatively stable and impermeable blanket.

Application of polyphosphate treatment can be made with usually available farm equipment, i.e. tractors, disks, grain drills, fertilizer spreaders, etc. Costs are much lower than for other acceptable methods. Polyphosphate costs range from $10 to $12 per hundred pounds, treatment for 2,000 square feet. The total costs, including labor and equipment, range from $300 to $386 per acre of pond area at 1957 prices.

REFERENCES

Arnow, Theodore, "Ground Water Resources of Columbia County, New York," N. Y. Dept. of Cons., Water Power and Control Comm. Bul. GW-25, 1951

Ashley, George H., "Geologic Map of Pennsylvania," Pa. Dept. of Internal Affairs, Topo. and Geol. Sur., 1931

Butts, Charles, "Geology of the Appalachain Valley in Virginia," Va. Geol. Survey Bul. 52, 1940.

Cederstrom, D. J., "Geology and Ground Water Resources of the Coastal Plain in Southeastern Virginia," Va. Geol. Survey Bul. 63, 1945

Flint, R. F., "Glacial Geology of Connecticut," Conn. Geol. and Nat. History Survey Bul. 47, 1930

Kummel, Henry B., and Lewis, J. V., "Geologic Map of New Jersey," Geol. Survey of N. J., 1910-1912

Lambe, T. William, "Improvement of Soil Properties with Dispersants," Jour. Boston Society of Civil Engrs., April 1954

Lambe, T. William, "Soil Testing for Engineers," John Wiley and Sons, 1951

Mathews, Edward B., "Geology Map of Maryland," Md. Geol. Survey, 1933

Price, Paul; Tucker, R. C.; and Haught, O. L.; "Geology and Natural Resources of West Virginia," W. Va. Geol. Survey, Vol. X, 1938

Esso Farm News, "A Leaky Pond Can Be Cured," Spring 1957

UNPUBLISHED MEMOS., REPORTS, AND CORRESPONDENCE

Allaband, William H., Field Letter No. 11, State Cons. Engr., SCS, Richmond, Va., Sept. 1956

Decker, Rey, "Correspondence from SCS Soil Mechanics Laboratory to Northeast SCS Engineers, 1954-1957

Simonson, Roy, to Fred H. Larson, Soil Series Descriptions, Nov. 20, 1957, Memo and attachments

Weaver, M. M., "Report of Farm Pond Failures," SCS Report, Waterloo, N. Y., Nov. 1957

Wheeler, George E., "How to Interpret the Soils Mechanics Laboratory Reports on Leaking Farm Pond Materials," In-Service memo to Md. SCS personnel, Beltsville, Md., Aug. 1957

Wickline, E. V., "Common Chemical Helps Seal Farm Pond," SCS Report, Lewisburg, W. Va., Oct. 1957

POND SEALING WITH POLYPHOSPHATES

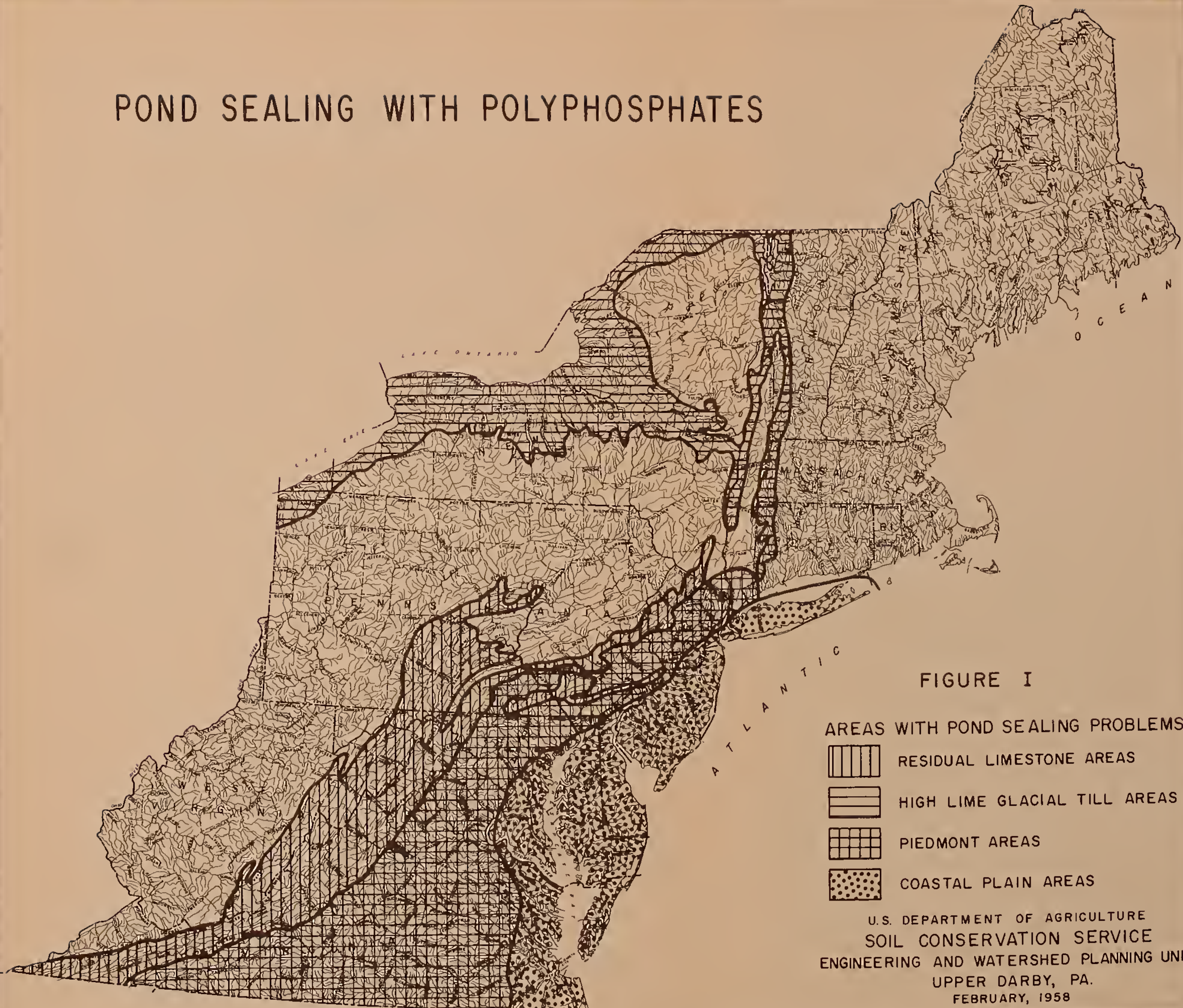


FIGURE I

Form SCS-205-A
(4/9/54)

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service

SOIL ANALYSIS REPORT
(Soil Mechanics Laboratory)

Source Harrisburg, Pennsylvania

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Lab. No.	Field No.	Sample Description	Depth	Gravel %	Sand %	Silt %	Clay .002 %	Clay .005 %	Disp. %	Total Salt %	Maximum Density (Lbs./Cu.Ft) Wet	Maximum Density (Lbs./Cu.Ft) Dry	% H_2O	Specific Gravity	
562169	1	Trexler Estates, Allentown	2-5.3	50	27	13	10	15	Tr	-	134.0	120.0	11.0	2.73	
562170	2	" "	1-2.2	41	10	32	17	29	*39 14 *59	-	122.0	102.0	20.0	2.71	

*-Silt + Clay

Lab. No.	Permeability (Cu.Ft./Sq.Ft./Day) W/C Only	Permeability (Cu.Ft./Sq.Ft./Day) WC+ 1#/20 TSPP**
562169	.0003	.0002
562170	.0001	.0002

**-Tetrasodium pyrophosphate

Figure 2. Typical Soil Analysis Report

Treatment	Original	Final before Freezing	Permeability cu.ft./sq.ft./day @ 1:1 after alternate freezing and thawing 3 cycles (12 days)	6 cycles (24 days)	Theoretical loss with 8' water thru 4" blanket $ft^3/ft^2/day$
Wet Compacted (WC)	.001	.0006	0.0105	0.021	0.5
WC/NaCl @ 1#/1 ft^2	.001	.0002	0.0002	0.00002	0.0005
WC/NaCl @ 1#/5 ft^2	.001	.0008	0.0004	0.00002	0.0005
WC/Pyrophos. @ 1#/20 ft^2			0.0004	0.00009	0.002
WC/Tri-polyphos. @ 1#/20 ft^2	.0003	.0002	0.0002	0	0
WC/Hexametaphos. @ 1#/20 ft^2	.0004	.0003	0.0004	0.00009	0.002

Figure 3 Permeability: Freezing-Thawing Tests Eisenhower Farm Pond, Pennsylvania

Freeze-Thaw Cycles	Sample 552367 Permeability in ft/day. Wet Compacted	W/C 1#/3 Salt	W/C 1#/20 Tri-polyphos	Sample 552368 Wet Compacted	W/C 1#/3 Salt	W/C 1#/20 Tri-polyphos.
Initial	.0005	.0007	.00009		.00003	None
1st	.0006	.0016	.0003	.0008	.00003	None
2nd	.0014	.00009	.0003	.0008	.00065	None
3rd	.001	.006	.0002	.005	None	None
4th	.0006		.00009	.008	None	None
5th	.0005		.00003	.035	None	None
6th	.0008					

Figure 4 Permeability: Freezing-Thawing Cycles Wm. Sharp Pond, Pennsylvania

POND, FREDERICKSBURG, VIRGINIA

(WALTER M. PRESTON)

SAMPLE 564623

TREATMENT	PERMEABILITY (CU.FT./SQ.FT./DAY, 1:1 HEAD)
Dry Tamp	0.14
Dry Tamp + 1/20 TSPP*	0.14
Wet Tamp	None in ten days
Wet Tamp + 1/20 TSPP	None in ten days

* Tetra-sodium-pyrophosphate

Figure 5 Dry Tamp Versus Wet Tamp Permeability

USDA-SCS-BELTSVILLE, MD. 1962